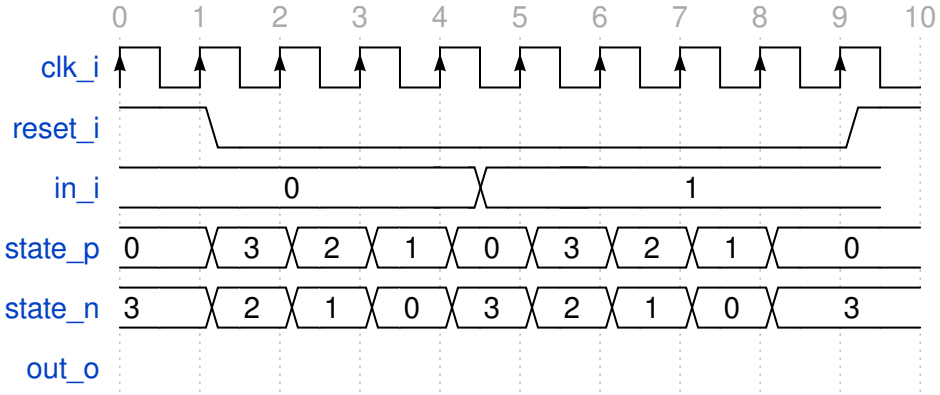
CON exam 07.07.2021 Matr.nr.: Last name:

The use of examination aids (e.g., calculators) is prohibited. Answers can be given in German or English. Please refrain from using lead pencils and red ink pens.

Grading scale: 00–25: insufficient 26–31: sufficient 32–38: satisfactory
39–44: good 45–50: very good

Q1. (10 points) **Finite State Machine:** Consider the FSM provided in the timing diagram below. The three top-most signals are 1-bit signals. The three signals at the bottom are 2-bit signals. in_i is an input signal for this FSM and state_p is the current state. state_n and out_o are outputs of the next state logic and output logic respectively.



(a) Give the two logical formulas of the next state logic.

(b) The output logic is defined in Verilog as below. Add the missing out_o line in the timing diagram (reminder: LSB is at index 0).

$$\text{out\_o}[0] = (\text{state\_p}[0] \vee \text{state\_p}[1]) \vee \neg\text{in\_i}$$
$$\text{out\_o}[1] = \text{state\_p}[0] \wedge \neg\text{state\_p}[1]$$

(c) Draw the ASM diagram of this machine.

(d) Which type of Finite State Machine is this FSM? What is the name of the other type? What is their difference?

→

→

Q2. (10 points) **Pipelining:**

(a) Explain the motivation and concept of pipelining based on the following example. You have a single cycle machine with a critical path of 600ps. You are able split the path into three pipeline stages of 200ps each. What does it mean to insert a pipeline stage? Explain how this leads to a speedup. How much is the speedup (assuming a full and ideal pipeline)?

(b) Assume the three pipeline stages `IF`, `ID` (includes reading the operands from the register file), and `EX`. This pipeline executes the four instructions below. Explain the problem arising in the pipeline with this code snippet. Explain two approaches to resolve this problem.

(c) Complete the diagrams below for both approaches and show which pipeline operation is performed at what clock cycle for each instruction of the code snippet. Assume an empty pipeline before starting the execution. State the total number of needed clock cycles for the execution of the code snippet for both approaches.

(d) Rewrite the source code to solve the problem purely in software.

(e) What defines the programmer's visible architectural state?

```
ADDI x2, x1, 0   # I1
ADDI x3, x1, 5   # I2
ADDI x4, x3, 3   # I3
ADDI x5, x1, 7   # I4
```

Q3. (10 points) **Assembly:**

(a) Transform the following C-code to RISC-V assembly. All local variables of the C-code **must** be allocated on the stack. The global variable `g` is located at address `0xF00`. The RISC-V calling convention must be followed. The assembly startup code including the initialization of the stack is provided below. Write the assembly code for the two functions at the foreseen locations.

(b) Draw the stack including known values, variable names, stack/frame pointer for the following locations in the program:

i. After the last instruction of the prologue of `main`.

ii. Before the call instruction in `main` and before the first instruction of `add`.

```c
// Located at memory address 0xF00
int g;

int add(int* p) {
  return *p + g;
}

int main() {
  int a = 3;
  g = 4;
  return add(&a);
}
```

Assembly Reference

```
LW    rd,imm(rs1)
SW    rs1,imm(rs2)
ADD   rd,rs1,rs2
ADDI  rd,rs1,imm
SUB   rd,rs1,rs2
JAL   rd,imm
JALR  rd,imm(rs1)
```

```
_start:
  ADDI sp, zero, 0x700
  JAL ra, main
  EBREAK

  add:

      main:
```

→

Q4. (10 points) **IPv4:**

(a) How many addresses are assigned to an IPv4 network with subnet mask 255.255.255.224? [1 point] Give the CIDR suffix for this IPv4 network. [1 point]

(b) What does TTL stand for? [1 point] Which problem does this header field solve? How? [2 points]

(c) A router implements NAT and wants to forward a packet to a host. Hence, the destination IP address is replaced. What else needs to be done? Which header field(s) are affected? [2 points]

(d) Explain the SMURF attack [3 points]

Q5. (10 points) **HTTP & DNS:**

(a) Explain idempotence in the context of HTTP. Is HTTP OPTIONS idempotent? [2 points]

(b) List and explain the new features introduced by HTTP 2.0 [4 points]

(c) What is the purpose of a non-authoritative name server? [1 point]

(d) Give three examples of ccTLDs [3 points]

Good Luck!